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GEOTECHNICAL ENGINEERING DISCUSSION DOCUMENT

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GEOTECHNICAL ENGINEERING: DISCUSSION DOCUMENT

by

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ABSTRACT

This report presents an outline of the activities of the Geotechnical Engineering Section of the Surface Mining Laboratory. It is prepared for distribution to the mining industry as a basis for discussion. The current status and a proposed future work plan are outlined, cooperative research projects with the Industry are described and the significance of such research is discussed.

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ÉTUDES GÉOTECHNIQUES: DOCUMENT D'ÉTUDE

par

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RÉSUMÉ

Dans ce rapport, l'auteur donne un aperçu des activités de la Section des études géotechniques du Laboratoire d'exploitation minière à ciel ouvert. Le rapport a été préparé en vue d'être distribué aux membres de l'industrie minière afin de servir de point de départ aux discussions. Il présente les grandes lignes d'un projet de travail futur et donne une description de la situation actuelle des projets de recherche conjoints avec l'industrie. L'importance de ces activités de recherche est également discutée.

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INTRODUCTION

The principal activities of the Geotechnical Engineering section include rock characterization, geological structures, ground movement monitoring, stability of slopes, benches and tailing dams, artificial support, modelling and instrumentation. This report presents an overview of the current status of the activities and also a work plan for the future. It is intended for circulation to industry for comment with a view to tailoring the work plan in keeping with industry's needs.

This report outlines current projects as well as those in preparation. Industry support and participation in any specific project will alter the order of priority of the research activities.

Resources alloted to the activities of this section are 2.5 person years and $100K (excluding salaries and overheads) per year.

CURRENT STATUS

Several projects which have been recently completed or are under investigation are described below.

SURFACE SUBSIDENCE

CANMET working with Westar Mining Ltd. in a jointly funded project developed a unique remote sensing system for measuring subsidence-induced surface movements. The system uses tiltmeters to sense ground movement and radio telemetry to transmit data. In addition, techniques were developed to assess subsidence using aerial photogrammetry. The two systems were compared and validated during a two year experimental program. Photogrammetry proved to be accurate to $\pm$ 8 cm. Progress has been made in perfecting the interpretation techniques. The results were compared with the measurement data from surveying using EDM (Electroptical Distance Measurement).

It must be stressed that this study was associated with mining a thick and steep coal seam in rugged conditions of the Rocky Mountain Region of western Canada. No previous knowledge on the behaviour of rock strata

in similar conditions had been available in Canada and no case histories have been documented elsewhere which could be used for comparison or prediction. Therefore, strata mechanics studies at the hydraulic mine were of major importance not only for the mine itself but generally for any future application in other mining areas with similar mining conditions.

OPEN PIT SLOPE/TAILING DAM MONITORING

Tiltmeter System

Discussions with Syncrude suggested two areas in which CRL's Surface Mining Laboratory's (SML) computerised telemetry might be deployed: firstly to monitor tiltmeters situated close to the draglines to warn an impending failure that might result in the loss of a dragline, secondly to monitor the stability of the tailings dam where underlain by the plastic clays of the Clearwater Formation.

Initial trials have shown that transmission is unaffected by electrical noise emanating from the nearby draglines and associated electrical supply lines. It appears that the system will play a role in increasing the efficiency of the Syncrude geotechnical program and can be interfaced to sensors previously in use at the mine.

Microseismic Monitoring of Slope Movements

Under a "Letter of Agreement" with the U.S. Bureau of Mines (USBM) a microseismic monitoring system developed by the USBM Denver Research Centre was tested at Cardinal River's open pit coal mine. The purpose of this microseismic slope failure detection system is to give an early warning of an impending pit slope failure. Field tests were carried out in co-operation and with the assistance of the staff of the USBM. These tests indicated that microseismic monitoring can be used for slope failure detection but the system should be installed as early as possible before any significant movement of the pit slope occurs. The test results are analyzed and documented in research reports.

DEVELOPMENT AND EVALUATION OF GEOTECHNICAL TEST METHODS

Different test methods for determining rock properties can be divided into appropriate groups based on the following main criteria: (a) Portability of the instrument, (b) Degree of precision, (c) Laboratory or in situ method, (d) Complexity of the procedure, and (e) Cost. The method of evaluation includes a review of the existing work, theoretical analysis and practical tests both in the laboratory and in the field. The following test methods have been evaluated for their suitability to test soft rocks:

- The point load test: systematic evaluation
- The microhardness test: systematic evaluation
- Protodyakonov test: preliminary evaluation
- Rebound hammer: preliminary evaluation

The point load test and the microhardness technique appear to be very useful. The rebound hammer method should be used only for preliminary evaluation. The Protodyakonov method appears to be a simple but reliable method but is more suitable for brittle rocks, for example, bituminous and higher rank coal, sandstone, siltstone, etc.

ARTIFICIAL SUPPORT OF SLOPES

This work is initiated under a research contract awarded to Hardy Associates (1978) Ltd. on developing design criteria for steeply dipping footwall stability. This was submitted as an Unsolicited Proposal.

The study includes evaluation of geological data, designing and monitoring of slope stability as well as stabilization of slopes. The project is scheduled to be completed by the fall of the current fiscal year. The output will be a design manual for the artificial support of steeply dipping footwalls. This project includes financial contribution from Crowsnest Resources' Line Creek Mine. More details on this project are described later under "Proposed Work Plan" of this project.

OTHER ACTIVITIES

Open Pit Slope Design

The Laboratory has initiated a cooperative project with TransAlta Utilities Corporation to evaluate an open pit slope stability design model. This will be funded jointly at approximately 40/60 level by CANMET and TransAlta respectively. The SPDR (Stress-Property-Deformation Relations) technique will be utilized to develop a finite element computer model for slope stability design.

Borehole Geophysics

A consortium of private companies has developed two projects on borehole geophysics with the active participation of the Laboratory.

The main objectives of these projects are to establish correlations between borehole geophysical data and geotechnical/hydrogeological properties and to study different applications of borehole geophysics in mining and geohydrology. The whole activity has been split into two parts: coal and oil sands. The coal project is funded by AOCRT at 50/50 level. The oil sands project is under consideration as an Unsolicited Proposal submitted to D.S.S. and no decision has been at time of writing.

Oils Sands Geophysics

A research contract awarded to Terracon Geotechnical Ltd. for work on the application of geophysics in oilsands was directed at the problem of sedimentary structures (Channel cross bedding) that provide potential slope failure surfaces. The work concludes that the offending clay bands are for the time being undetectable from the surface but that it is conceivable that seismic work could reveal the localised cross bedding.

PROPOSED WORK PLAN

This section deacribes the projects either initiated before and still in progress or proposed for the next five year period. The work elements

described are ambitious given the limited resources assigned to the Geotechnical Engineering section. Cooperation and support from industry will be needed to complete these projects on time.

GROUND MOVEMENTS MONITORING

Stability Monitoring

The following work is scheduled this year at Syncrude:

1. Expansion of telemetry system during spring/summer 1986 to cover the mining/tailing area.

2. Adaptation/expansion of the slave station to monitor other sensors (piezometer/inclinometers etc.) at mining/tailing areas as well as extension to monitor greater numbers of sensors per slave at greater distances.

While depending upon the results of the above, a work plan for the years 1987 - 1990 has been prepared for the development of a multipurpose mine data telemetry system based on new generation micro-processor instruments to supersede the six year old radio telemetry equipment. This new system will be used for a variety of field monitoring activities including stability monitoring of rock and soil slopes, tailing dams and wastedumps.

Microseismic Monitoring of Slope Movements

An initial study on the microseismic monitoring of slope movements indicates that this technique has promise for warning of impending pit slope failures. However, considerable further study is required to develop the method as a pridiction tool suitable for application in surface coal and oil sands mines in Canada. Some of the important issues to be addressed are: number and location of stations required, noise elimination methods, simplification of the station installation procedures, definition of conditions where microseismics can work independently and where they

must be used in conjunction with other methods, correlation between the intensity of microseismic activities and the probabilities of slope failure, etc.

No further work in this area will he undertaken without industry support. The Geotechnical Engineering section does not have the resources to mount extended field campaigns.

SLOPE STABILITY MODELLING/ANALYSIS

SPDR Technique

A jointly funded (40/60) co-operative project has been initiated between the Laboratory and TransAlta Utilities Corporation, Calgary to evaluate the SPDR integrated system for slope stability design in one of TransAlta Utilities' surface coal mines.

The objective of the proposed work is to validate for Canadian conditions a new quantitative method of slope design for surface coal and oil sands mines that may substantially increase safety and productivity. This quantitative method achieves these benefits by constructing a finite element computer model of the mine, which is capable of simulating the site-specific geomechanical behaviour.

The site-specific ground properties of the individual strata and of all the critical bedrock units are measured directly, in situ, by means of the Serata Stress/Property Measuring System - a system developed especially for this purpose.

The computer model, calibrated to this in situ stress/property data, is to be used, first, to predetermine the effects of variations in the geology on the stability of open pit slopes, and later, to conduct computer testing of pit design modifications to optimize slope design.

This project will be carried out partly through in house work by the Laboratory and TransAlta Utilities and partly through a research contract and is scheduled to be completed by April 1987. Further work on the SPDR technique including field trials will depend upon the outcome of this project and the continuation of industry participation.

ARTIFICIAL SUPPORT OF SLOPES

The research contract to develop design criteria for steeply deeping footwall stability in the Mountains will be completed this fall. The objective of this project is to prepare a design manual by completing the following work: geologic and geotechnical data collection, detection of geometrical problems, development of failure models, refinement of analytical methods, development of stabilization methods and design criteria and monitoring stability.

Depending on the outcome of this project, which will be documented in a design manual, a follow up demonstration at a suitable mine site could be initiated as a cooperative project with industry. The long term goal is to develop a series of design manuals for remedial control of failing geotechnical surface mine structures.

STUDY AT AOSTRA'S UNDERGROUND TEST FACILITY (U.T.F.)

AOSTRA's main intention in the near term is to evaluate the steam assisted gravity drainage process for bitumen extraction using horizontal wells drilled from tunnels beneath the oil sands.

From the geotechnical point of view there are three areas which need to be investigated: (a) Permeablility for the flow of bitumen (b) Stability of the access roadways and (c) Integrity of the wellbores.

There is virtually no data available on in situ geotechnical characteristics of oil sands and the adjacent strata at these depths. This includes such basic and fundamental properties as in situ strengths and stresses, the effects of exsolving gases and permeability. Similarly, there is very little reliable data available on fracturing characteristics of oil sands. This information is fundamental to the design of all in situ bitumen extraction processes.

In view of the above fact, the Laboratory in cooperation with AOSTRA and their private sector partners is planning to develop a work plan to study the behaviour of the oil sands and adjacent rock strata at the UTF. This will be useful in designing in situ recovery of bitumen whether from the surface or from underground.

MODELLING

Physical and Numerical Models

Substantial advances through study on models whether physical or numerical have been made in the past and will continue to be made in the future.

It is therefore proposed to develop a long term work plan for models research of rock and soil slopes and spoil dump stability. The SPDR technique as discussed before is an element of such a model of open pit slopes. Developing a reliable geotechnical data base is essential for such work.

To be useful models must be validated with case histories. This validation process defines the accuracy and limitations of the model. Industry participation at all phases is desirable to verify that the models meet real needs and are practical.

Geotechnical Data Base

A large amount of information exists on geotechnical characteristics. It is intended to gather the available information from various sources with a view to creating a data base. This data base would be used to develop models for improved mine design, in general, and the tackling of specific mining problems in particular. This will also be useful in developing suitable rock classification systems.

All geotechnical design work is predicated at least in part on rock properties. Different methods for determining rock properties, e.g. laboratory, in situ, micro and macro will be investigated depending on their importance to industry needs.

DESIGN, MONITORING AND CONTROL OF FAILING STRUCTURES

The design of most surface mining geotechnical structures is a compromise between cost and the need for stability for a finite time period. Overly conservative designs are too costly while inadequate designs can be even worse. This proposed work plan addresses design, monitoring and remedial control of surface mine geotechnical structures. By developing improved monitoring and design tools we can consider reduction of safety factors by reducing uncertainly but to do so we must

understand how to control failures. The economics favour a controlled failure approach where the structure is unstable in the long term but does not fail or can be economically controlled until after mining of that location is complete.

Our goal is minimum cost structures that can be monitored and cost effectivey stabilized when and if failures develop.

CONCLUDING REMARKS

The principal objective of the Geotechnical Engineering section is to conduct applied research that enhances the efficiency and economic performance of the Canadian surface coal and oil sands mining industries. Research to meet industry's needs is best accomplished within a framework of consultation and discussion.

CANMET's allocation of resources will be increasingly influenced by relevance to industry needs.

There are several projects planned for the current fiscal year which are jointly funded cooperative research projects and it is expected more such cooperative projects will be initiated in near future.

This report describes the current status and a proposed five year work plan for the Geotechnical Engineering section of the reorganized Surface Mining Laboratory. It is intended to be circulated to the industry for comments so that the various work elements can be modified and priorized in keeping with industry's needs.

Accomplishment of this ambitious work plan will require strong support and cooperation from industry. Existing labotatory resources are insufficient to accomplish all of the identified tasks. While the Surface Mining Laboratory will endeavour to obtain additional resources, progress on the work elements is dependent upon industry support and cooperation.

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